APPENDIX J: Glossary of OBPR Research Thrusts[8]

Bioastronautics Research Division

A. Biomedical Research & Countermeasures Program

Behavior & Performance
Research focused in six areas which include: 1) perception and cognition, 2) human physical performance, 3) personal, interpersonal and group dynamics, 4) habitability, e.g. human factors – how the person responds to the human-machine interface, 5) circadian rhythms, and 6) advance technology development in these areas.

Clinical/Operational Medicine
Research to define medical risk, test proven ground medical treatment and technologies for use in spaceflight, develop new medical preventatives or rehabilitation therapies for use by astronauts in space or on their return to Earth, and the development of advance technology for use in space for diagnosis, biomedical technical training and continuing medical education, and therapeutics.

Environmental Health
Applied research to study barophysiology, microbiology and toxicology and to develop new technologies in these areas. The purpose of this program is to better understand the specific risks, and how to prevent and treat potential health problems that occur because of the microgravity, and the confined and isolated living quarters.

Integrated Physiology
Inter-system research on the physiological and behavioral alterations that occur during spaceflight. The purpose is to define the systemic changes that occur to other organs by perturbations in another organ system, determine the mechanisms for these changes and the development of countermeasures or treatment modalities to reverse or prevent the deleterious effects associated with space flight. Examples include "how spaceflight induced physiologic responses of the vestibular system cause problems in the autonomic and cardiovascular systems" or "how changes in the digestive tract effect the maintenance of the musculoskeletal system.

Organ System Physiology
In addition to classical physiologic research, research to understand the underlying molecular, genetic, and cellular factors, and other underlying processes that result in spaceflight changes of a single organ and the development of "countermeasures" to prevent, slow or recover from maladaptive spaceflight induced changes to the specific organ. Examples include organ disciplines including cardiovascular, bone, muscle, vestibular, etc.

[8] Alphabetical within programs

Radiation Health
Research to determine the risk and prevention of health problems induced by space radiation. Specifically research that will reduce the uncertainties associated with predicting the excess risk of carcinogenesis resulting from radiation exposure during space flight. Support ground-based research studying the biological effects of heavy ions using the NASA facility at Brookhaven for the evaluation of risk factors to radiation-induced carcinogenesis and other radiation-induced health problems. Studies will center on genetic biological research, bioengineering and radiation protection through research in radiation physics and shielding materials as appropriate and advanced technology development for the diagnosis, and prevention of radiation damage to space travelers.

B. Advanced Human Support Technology Program

Advanced Life Support
Advanced life support project conducts R&TD to provide: temperature and humidity control; atmosphere purification, and revitalization; water recovery and management; waste management; and food management. Integrated life support systems testing and validation has also been conducted by the ALS project.

Environmental Monitoring and Control and Advanced Environmental Monitoring and Control
EMC research and technology development encompasses monitoring the internal environment of a human occupied spacecraft, including the atmosphere, water supplies, and all surfaces. Monitoring implies continuous oversight of the status of these areas over time to ensure that conditions are maintained within acceptable limits and Control implies some form of feedback to the systems responsible for maintaining each parameter.

Extravehicular Activity and Advanced Extravehicular Activity
Extravehicular activity is work conducted outside the pressurized volume of a crewed space vehicle/facility. The EVA equipment consists of: the spacesuit, the primary life support system (pressurized oxygen, ventilation, and removal of CO_2, water vapor, and trace contaminants), thermal conditioning, and the tools (including robotic tools) that enable the EVA crewmember to accomplish the necessary tasks.

Space Human Factors Engineering
Human factors focuses on the role of humans in complex systems, the design of equipment and facilities for human use, and the development of environments for comfort and safety. Subject areas for human factors research include ergonomics, biomechanics, anthropometrics, workload, and performance. Design of systems and operations for human activities in space is called space human factors engineering.

Fundamental Space Biology Division

Note: All research areas focus on the effects of the space environment on the biological processes identified for each area.

Cell and Molecular Biology

Research in this area addresses how basic cellular function and properties (e.g., mechano-reception, signal transduction, gene regulation and expression, proteomics, integrin function and structure, cytoskeletal structure and function, etc.) may be directly or indirectly impacted by altered gravitational force and other space-related effects. Of particular interest are molecular and cellular studies associated with the physiological changes seen in whole animals in response to the space environment.

Developmental Biology

Research to determine the role of gravity in normal development and function, how gravity and other aspects of the space environment may affect the capacity of organisms to reproduce, and the mechanisms by which subsequent generations are affected. Of particular interest is the development of systems and structures involved in gravity sensing and response.

Evolutionary Biology

Research to understand the capacity for terrestrial organisms to evolve in the novel environment of space, and the role gravity has played in terrestrial evolution.

Gravitational Ecology

Research to understand how the space flight environment might affect the structure, function, and the evolution or stability of ecosystems, particularly as they might relate to spacecraft or planetary habitats.

Molecular Structures and Physical Interactions

Research that emphasizes the physical effects of the space flight environment, such as static boundary layer effects on gas exchange, changes in heat transfer, lack of convective fluid movements, and alterations in diffusion-limited metabolic processes, on the functioning of single-celled and multicellular organisms.

Organismal and Comparative Biology

This element elucidates the effects of chronic exposure to altered gravity and/or other space-related factors on normal physiology, metabolism, and performance of animals and plants, and compares or contrasts them among different organisms.

Physical Sciences Division

A. Fundamental Microgravity Research

Condensed Matter and Quantum Phenomena[9]
Cooperative phenomena in non-equilibrium systems; atom laser studies, low-temperature atom condensates.

Fluid Stability, Dynamics, and Rheology
Fundamental aspects of fluid behavior in low gravity, including interfacial phenomena and multiphase flows.

Fundamental Laws and Benchmark Data to Test Theories[9]
Tests of fundamental laws of physics and integrated theories requiring innovative experimental techniques. Research spans second order phase transitions in low temperature physics, relativity experiments using high accuracy atomic clocks, and fundamental aspects of materials research and combustion science.

Kinetics, Structure, and Transport Processes in Physico-Chemical Systems
Transport phenomena, kinetics, and non-equilibrium processes. Nucleation (of bubbles, soot, crystallization, etc.); rates of chemical or metabolic reactions (during combustion or cellular activity). Formation of particles such as fullerenes and soot.

Phase transformation, pattern formation, and self-assembly in physico-chemical systems[10]
Physics of processes leading to order and structure in systems of technological interest: solidification processes in metals, defect formation in crystalline materials, self-assembly in colloidal suspensions, dynamics of foams and granular systems.

Thermo physical, Physical-Chemical, and Biophysical Properties
Transport and thermodynamic data on materials and systems of technological importance.

B. Biotechnology and Applications Program

Bio-inspired and Microfluidics Technologies
Interdisciplinary research projects bringing expertise from biology, physics, chemistry, and engineering to focus on understanding the synthesis and function of macromolecular assemblies. Application to new experimental methodologies for ISS and other space-based research stressing miniaturization and automation.

[9] Includes research targeting issues involving the physics of phase transitions.

[10] Research targeting issues in materials science; phase transformation is a well-defined and accepted nomenclature in the field of metal alloys.

Cell Science and Tissue Engineering
Applications of low-shear stress culture technology for three-dimensional mammalian cell systems; effects of mechanical stresses on cell systems. Enhancement of technology for three-dimensional tissue culture and engineering using the NASA Bioreactor as a foundation.

Energy Conversion and Chemical Processing
Combustion research on problems of energy- and environmentally-related interest.

Materials Synthesis and Processing
Reactive processes for synthesis of novel materials, including carbon nanostructures and ceramics for biomaterials applications.

Structural Biology
Micromechanics of protein crystal growth of biological macromolecules and factors controlling crystal quality; development of technologies for obtaining high-diffracting crystals of scientific interest.

C. Engineering Research Enabling Exploration

Biomolecular Systems Technology and Sensors
Integrated research projects developing technologies to monitor biological signals and processes relevant to health care, cosponsored by the NIH/NCI

Fire Safety, Spacecraft Fluid System Engineering Research
Ignition and propagation of fires in low-gravity; detection and extinguishment technologies; prediction and control of normal and cryogenic liquid behavior in vehicle systems.

Mission Resource Production and Robotic Exploration
Research on gravity-dependent phenomena inherent to technologies required for planetary exploration missions. Basic research supporting mission architecture studies and chemical process design in non-Earth environments. Examples of currently supported projects include process studies on the separation of CO_2 from the Martian atmosphere and the production of oxygen from lunar soils.

Propulsion and Power Systems
Heat transfer, thermal hydraulics, and high temperature/extreme environment materials relevant to vehicle propulsion and power technologies; microcombustion technologies for high density energy storage.

Radiation Protection
Interaction of space radiation and materials; prediction of crew radiation exposure; effective shielding strategies for crew and equipment.

Research Integration Division (Space Product Development)

A. Commercial Applied Sciences

Advanced Materials
Advanced materials research supports zeolite crystal growth for refining and chemical industries; dilute gas sensors; ceramic powders/non-oxide ceramic production; improved casting technologies and thermophysical properties research; optical fiber production for optoelectronic devices; chemical sensors, and; superconducting wires for transmission applications. This field of research benefits from the use of microgravity to alter physical properties of the materials of interest and to provide insight into previously unknown phenomena, processes, and interactions.

Agribusiness
Agribusiness explores plant research under microgravity conditions to examine plant structure absent the force of gravity. Insights gained may lead to improved agricultural products. The research also adds to the base of knowledge in the fundamental science area of plant research and contributes to other fields of knowledge, such as plant-based pharmaceutical development.

Biotechnology
The Commercial Space Centers have established substantial research collaboration with pharmaceutical firms in the field of biotechnology. Pharmaceutical CSC partners include: Amgen, Bristol Myers-Squibb, Merck, Eli Lilly, BioCryst (spinoff of a CSC), Vertex Pharmaceuticals, Abbott Labs, Upjohn, Schering Plough, and other pharmaceutical firms presently affiliated with the CSC program. This research area has proven the broadest and most successful among the three areas of commercial applied sciences in terms of market support, industry investment and near-term potential for positive economic impact.

B. Commercial Engineering Research and Technology Development

Power Generation, Storage, and Transmission
Power systems have many applications. For example, advanced solar cells, batteries and flywheels, are of interest to a wide variety of industry partners for use in electric vehicles, uninterruptible power supplies, solar electric power generators, etc.

Propulsion
Space propulsion systems include electric, chemical, hybrid, and waste gas propulsion systems. Propulsion research will enable US satellite manufacturers and providers of launch services to be more competitive in an increasingly demanding market. Advanced propulsion systems would make it possible to use smaller and cheaper transfer stages and could greatly improve spacecraft reliability and lifetime.

Remote Sensing and Autonomous Systems
Remote sensing technology, such as hyperspectral imagery, has valuable commercial and scientific applications from environmental monitoring to identifying oil and gas deposits on earth to exploring and developing extraterrestrial resources. Autonomous systems that can rendezvous and dock enable refueling, maintenance, and orbit transfers of commercial and government satellites. These systems could greatly reduce reliance on ground control, providing advantages

for scientific as well as commercial spacecraft. Greater autonomy would reduce the amount of tele-operation required in future planetary exploration.

Robotics and Structures
Robotic systems could be used in conjunction with or instead of astronauts to perform a wide variety of tasks, including inspecting, servicing, and repairing the station; manipulating and placing large objects outside the ISS, and servicing scientific experiments. Structures could improve the precision and reduce the weight of communications antennas, could lead to improved lightweight solar collectors antennas, and reflectors for low-cost robotic spacecraft, and could also reveal additional design options for ultralight spacecraft.

Telecommunications
The ERTD category addresses technology development issues of importance to commercial communications satellites, including development and testing of phased array antennas, characterization of the on-orbit radio frequency environment, demonstration of high-data-rate communications, validation of complex on-board processors accomplishing advanced signal processing tasks, testing of optical communications devices, and deployment of unique antenna structures.

Thermal Control
Thermal control consists of devices for thermal transport and storage (heat pipes, two-phase pumps, phase change materials); refrigeration subsystems (thermoelectric devices and cryogenic coolers); advanced radiators (composites); and insulation.